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COMMONWEALTH OF MASSACHUSETTS
PROPOSED DESIGNATIONS OF
AIR QUALITY MAINTENANCE AREAS

MARCH 1974

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I. BACKGROUND

A. The Federal Requirements

On June 18, 1973, the Environmental Protection Agency promulgated in the Federal Register (CFR 51.12) a requirement that States undertake work to amend their State Implementation Plans (prepared pursuant to the Clean Air Act) so as to take account of air pollution likely to occur as a result of future growth and development. Specifically, EPA required the States to engage in a two-stage planning process, as follows:

By March 18, 1974: The States are to identify "Air Quality Maintenance Areas" (initially termed "Areas of Concern") in which air pollution levels currently exceed national standards or in which, because of expected growth and development, air pollution levels may exceed national standards in ten years. The States are to submit a list of such areas to EPA by the March deadline, for EPA's approval and promulgation in the Federal Register by June 18, 1974. It is in fulfillment of the requirements of this stage of the planning process that Massachusetts has undertaken the work described in this report.

By June 18, 1975: The States are to analyze in detail the impact of expected growth and development on air quality in the Air Quality Maintenance Areas. This analysis shall look not only at the increased air pollution which is expected to arise directly from new commercial, industrial, and residential development but also that anticipated as a result of related increases in demand for electricity and heat, motor vehicle traffic, and production of solid waste. Based on this analysis, the States are to submit a plan to prevent national standards from being exceeded in the next ten years. The work involved in this stage will be undertaken by Massachusetts and the other States following promulgation of EPA-approved Air Quality Maintenance Area designations.

Towards the end of January, 1974, EPA forwarded to the States a document entitled "Guidelines for Designation of Air Quality Maintenance Areas." This document, which was modified on February 14, 1974, establishes the procedures to be followed, the criteria to be applied, and the kinds of data to be used by the States in determining which geographic areas should be proposed as Air Quality Maintenance Areas. The Guidelines call for a three-step analytical process to be undertaken, with the basic geographic units of analysis to be the Standard Metropolitan Statistical Areas (SMSAs) of a State. Gross indicators of growth in the 1970-85 period (Growth Factors) are to be applied to 1970 emission levels, these in turn being deflated by certain "Reduction Factors" reflecting the application of controls on sources of pollution between 1970 and 1985. The projected 1985 emissions are then to be used to estimate 1985 air quality. The Guidelines also specify that the current so-called energy crisis is not to be taken into account in making the required projections.

The analysis which is required by the EPA Guidelines is "pollutant-specific," that is, it is carried out with regard to five air contaminants for which there are national standards. The five contaminants are: suspended particulates, sulphur dioxide, carbon monoxide, oxidants, and

nitrogen oxides. An SMSA which is not expected to meet national air quality standards for any one or a combination of the five contaminants must be designated an Air Quality Maintenance Area.

B. Administrative Structure

The work undertaken in Massachusetts to comply with EPA's requirements for the designation stage of the air quality planning process was carried out under the auspices of the Governor's Resource Management Policy Council, through a sub-group called the Task Force on Air Quality. The Task Force was originally called together to deal with the issue of "complex" or "indirect" sources of air pollution and its mandate was later broadened to air quality planning in general.

The Task Force, of which the Secretary of Environmental Affairs has been designated as "Lead Secretary", contains representation from the Bureau of Air Quality Control of the Department of Public Health, the Department of Community Affairs of the Executive Office of Communities and Development, the Executive Office of Manpower Affairs, the Executive Office of Transportation and Construction, the Bureau of Transportation Planning and Development of the Department of Public Works, the Executive Office of Consumer Affairs, and the Governor's Office. It has also had representation from Regional Planning Agencies. It is chaired by the Director of Planning of the Office of State Planning and Management.

The current planning effort was a cooperative undertaking, involving contributions from most agencies represented on the Task Force and review and comment by all. Nonetheless, the bulk of the work was technical, and in the technical aspects the Bureau of Air Quality Control was the major contributor.

II. SUMMARY OF STEPS IN DESIGNATION PROCESS

A. The Three-step Procedure

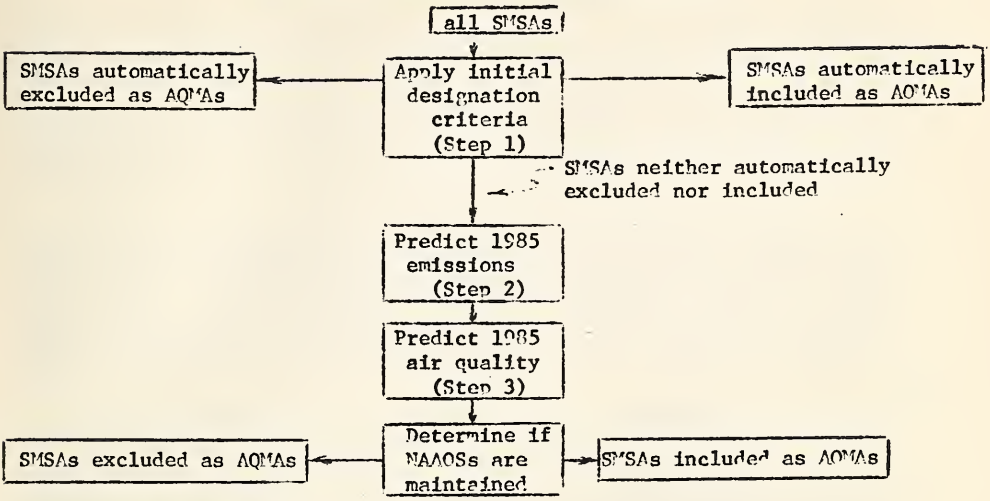
EPA's designation procedure (see Table 1) involves narrowing down the number of SMSAs in a State to be considered for designation as Air Quality Maintenance Areas through successive analytical steps, as described below.

1. Application of initial inclusion/exclusion criteria: In this step, taking each SMSA one by one, the State applies a number of criteria relating to specific pollutants. As a result of the application of these criteria, the State eliminates obvious non-problem areas from designation and further analysis, determines obvious problem areas which will be designated without further analysis, and pinpoints those areas in which additional analysis will have to be carried out before it can be determined whether designation is required or not. Most of the initial designation criteria are based on recent pollution levels. Three of the criteria, however, involve the application of Growth Factors, which are discussed below.

2. Prediction of 1985 emissions: This step is applied only to those SMSAs which have not been automatically included or automatically excluded as Air Quality Maintenance Areas as a result of the application of the initial inclusion/exclusion criteria. In this step, emissions of specific contaminants from specific categories of sources are projected, using Growth Factors to take account of increases in the volume of activity from a given source category which may cause pollution and Reduction Factors to account for the lesser amount of pollution to be expected from any given volume of activity from a source category because of implementation of pollution controls. For each contaminant for which analysis may be required as to a particular SMSA, emissions from specific sources are first projected to 1975, the year in which existing State Implementation Plans are expected to be fully effectuated with consequent reductions in pollution. Emissions are then projected to 1985, the period 1975 to 1985 being assumed to be subject to the controls effective in 1975, but to no further controls, except for transportation sources and new industrial process sources.

3. Prediction of 1985 air quality: This step involves modelling the air quality of an area by utilizing the emission estimates obtained in the preceeding step in certain specified equations. The results of this modelling process indicate whether or not, and to what extent, national ambient air quality standards (NAAQS) may be exceeded in 1985 in the geographic area analyzed.

TABLE 1. STEPS IN DESIGNATION PROCEDURE


all SMSAs
Apply initial designation criteria (Step 1)
SMSAs automatically excluded as AQMAs
SMSAs automatically included as AQMAs
SMSAs neither automatically excluded nor included
Predict 1985 emissions (Step 2)
Predict 1985 air quality (Step 3)
Determine if NAAQSs are maintained
SMSAs excluded as AQMAs
SMSAs included as AQMAs

B. Growth Factors

Critical to the above analytical steps are the Growth Factors used in several of the initial designation criteria and in the predictions of 1985 emissions from sources of pollution. Projected population growth is, according to EPA, to be used as the factor to project increased emissions from solid waste disposal; projected growth in total earnings is to be used as the factor to project increased emissions from fuel combustion and miscellaneous other sources; and growth in manufacturing earnings is to be used to project growth in emissions from industrial processes. The numbers used for population and economic projections are highly significant, then, in making predictions of future air quality problems and, therefore, in determining Air Quality Maintenance Area designations.

In the EPA Guidelines for designation, it is suggested (but not required) that projections of population and earnings prepared by the Bureau of Economic Analysis (BEA) be used by the State. For Massachusetts, the BEA projections seem less accurate than projections developed at the State level to portray likely growth and development in the period 1970 to 1985.

The BEA projections appear to be somewhat questionable on two grounds. First, BEA has defined SMSAs as consisting of collections of whole counties, while in New England, SMSAs are officially defined (by the U.S. Office of Management and Budget) as collections of individual cities and towns, not necessarily constituting whole counties. For instance, the BEA projections for the so-called Pittsfield SMSA include the entirety of Berkshire County, with a total 1970 population of 149,660, while the official SMSA includes

only a portion of that county, with a total 1970 population of 79,797. Second, the BEA projections show much higher rates of growth in Massachusetts than appear consistent with past trends. For instance, again in the case of the Pittsfield SMSA, BEA's projected growth rates from 1970 to 1985 in population, total earnings and manufacturing earnings are 32%, 97%, and 93% respectively. State sources suggest that population will be stable, that total earnings will rise by 33%, and that earnings in manufacturing will increase by 5%.

Use of the BEA projections would result in forecasts of extremely high levels of pollution for major portions of the State. Moreover, the BEA-selected areas differ significantly from the State's urbanized areas which appear to pose the most serious future pollution problems. Therefore, it was decided to exercise an option offered by the EPA guidelines--that of substituting State population and economic projections for the BEA projections.

On the side of population, several sets of projections were examined, and a set prepared by the University of Massachusetts for the Office of State Planning and Management was selected. These projections were prepared in a systematic manner with reasonable assumptions about migration and with a low fertility rate now generally considered realistic. For the economic variables, the Executive Office of Manpower Affairs prepared projections of total earnings and of earnings in manufacturing based on data from the Division of Employment Security.

Based on the above, new growth factors were derived for population, total earnings and earnings in manufacturing, for each of the SMSAs in Massachusetts. These new factors are shown in Table 2 below. The BEA growth factors are shown in Table 3 for purposes of comparison.

TABLE 2. NEW GROWTH FACTORS, 1975 and 1985
(1970 = 100)

SMSA	POPULATION		TOTAL EARNINGS		EARNINGS IN MANUFACTURING	
	1975	1985	1975	1985	1975	1985
Boston	102	107	111	182	96	105
Brockton	109	131	114	201	104	148
Fall River	99	97	102	133	89	75
Fitchburg	111	103	96	105	96	105
Lawrence	103	110	102	133	96	105
Lowell	111	129	117	220	108	165
Mass. portion of Providence	109	128	114	201	108	165

	132	122
	201	122
27	187	130
27	183	127

Continued -

SMSA	POPULATION		TOTAL EARNINGS		EARNINGS IN MANUFACTURING	
	1975	1985	1975	1985	1975	1985
New Bedford	96	98	103	165	102	133
Pittsfield	99	100	102	133	96	105
Springfield	102	107	102	133	93	92
Worcester	100	102	96	105	96	105

TABLE 3. BEA GROWTH FACTORS, 1975 and 1985
(1970 = 100)

AREA*	POPULATION		TOTAL EARNINGS		EARNINGS IN MANUFACTURING	
	1975	1985	1975	1985	1975	1985
Boston	109	128	124	185	123	146
Fall River-New Bedford	105	116	124	182	122	165
Pittsfield	110	132	131	203	131	193
Springfield	105	119	127	187	130	179
Worcester	107	121	127	189	127	174

---

*Area Descriptions

BOSTON AREA = Essex, Middlesex, Norfolk, Plymouth, and Suffolk Counties, including Boston, Lawrence, Lowell and Brockton SMSAs

PITTSFIELD AREA = Berkshire County, including Pittsfield SMSA

SPRINGFIELD AREA = Hampden and Hampshire Counties, including the Springfield SMSA

WORCESTER AREA = Worcester County, including Fitchburg and Worcester SMSAs

FALL RIVER-
NEW BEDFORD AREA = Bristol County, including Fall River and New Bedford SMSAs

Boston
Springfield
Worcester
Lawrence

None

Boston

None

None

III. INCLUSION/EXCLUSION ANALYSIS

A. Summary of Area Results

Table 4 below summarizes the results of the inclusion/exclusion analysis, applied to the ten SMSAs within Massachusetts and to that part of the Providence SMSA falling within the Massachusetts boundary. As shown in the table, Boston is automatically included as an Air Quality Maintenance Area because of sulphur dioxide and oxidant (ozone) levels and requires further analysis for carbon monoxide and suspended particulate levels; Springfield is automatically included as an Air Quality Maintenance Area because of oxidant levels; Worcester and Lawrence are not automatically included for any contaminant but require further analysis for suspended particulate levels· all other SMSAs are automatically excluded for all contaminants and require no further analysis.

TABLE 4. RESULTS OF INCLUSION/EXCLUSION ANALYSIS

INITIAL DESIGNATION STATUS OF MASSACHUSETTS SMSAs

Contaminant	SMSAs definitely included	SMSAs possibly included	SMSAs definitely excluded
Suspended Particulates	None	Boston Springfield Worcester Lawrence	all others
Sulphur Dioxide	Boston	None	all others
Carbon Monoxide	None	Boston	all others
Nitrogen Oxides	None	None	all SMSAs
Oxidants (ozone)	Boston Springfield	None	all others

B. Total Suspended Particulates (TSP)

1) Automatic exclusion: An area is automatically excluded for total suspended particulates ("TSP") if measured levels of TSP were below national ambient air quality standards for the past two years. The national standards required for this analysis for TSP are as follows: (a) 75 ug/M^3, annual geometric mean; (b) 150 ug/M^3, not to be exceeded more than once per year (e.g. second highest 24-hour average).

Readings on particulates are available for nine of the eleven SMSAs (all but Fitchburg and Brockton). Examination of the readings on particulates obtained at the least favorably located monitoring station in each of the nine SMSAs over the period 1972-73 shows that by this criterion all but

the Boston, Springfield, Lawrence and Worcester SMSAs are excluded. In accordance with EPA recommendations, the Brockton and Fitchburg SMSAs were also excluded because of a lack of data. Table 5 below shows the data on which the conclusions for all SMSAs (except Brockton and Fitchburg) are based.

2) Automatic inclusion: An area is automatically included for TSP if projections show it will not attain the national ambient air quality standards by 1985. Projections of TSP are discussed in Parts III & IV below.

TABLE 5. EXCLUSION DATA FOR TOTAL SUSPENDED PARTICULATES

	1972or73, Measured Average Annual Reading (Worst Year) In ug/M^3 (NAAQS: 75 ug/M^3)	1972or73, Measured 2nd Highest 24-Hour Average In ug/M^3 (NAAQS: 150 ug/M^3)
Boston	108	325
Brockton	No data	No data
Fall River	48	98
Fitchburg	No data	No data
Lawrence	65	156
Lowell	52	112
New Bedford	36	64
Pittsfield	52	125
Providence (Mass. portion)	43	95
Springfield	56	165
Worcester	72	295

C. Sulphur Dioxide (SO_2)

1) Automatic exclusion: An area is automatically excluded for SO_2 if a) measured levels of SO_2 were below national ambient air quality standards for the past two years, and b) measured levels of SO_2 in the base period multiplied by growth in SMSA earning from the period through 1985 yield levels less than the national ambient air quality standards. The national ambient air quality standards for SO_2 are expressed in terms of two criteria, independently applied: 1) 0.03 ppm annual arithmetic mean; and 2) 0.14 ppm second highest 24-hour average per year.

Examination of the readings on SO_2 obtained at the least favorably located station in each SMSA over the period 1972-73 shows that, by part "a" above, all SMSAs in Massachusetts are excluded. Application of part "b" above confirms this exclusion for all SMSAs except, however, for Boston. Table 6 below presents the data on which this conclusion is reached.

TABLE 6. EXCLUSION DATA FOR SULPHUR DIOXIDE

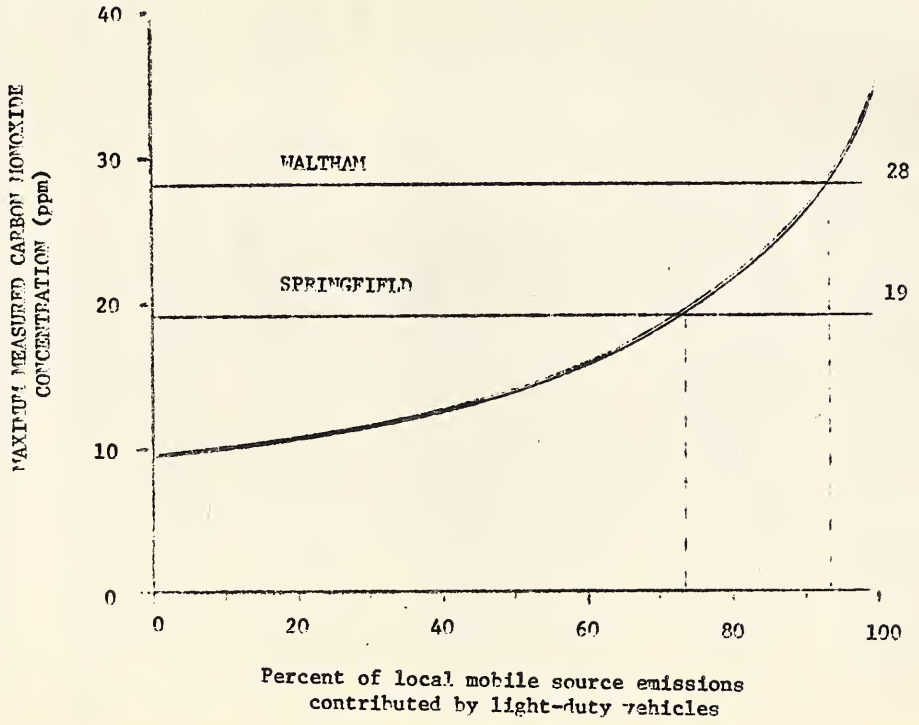
SMSA	1972or73, Measured Average Annual (Worst Year) in ppm	1972or73 Measured 2nd Highest 24-Hour Average in ppm	Growth Rate	1985, Estimated Average Annual in ppm	1985, Estimated 2nd Highest 24-Hour in ppm
Boston	.026	.084	1.82	.047	.153
Brockton	No data	No data	-	-	-
Fall River	.009	.031	1.33	.012	.041
Fitchburg	.011	.029	1.05	.012	.030
Lawrence	.011	.095	1.33	.015	.126
Lowell	.007	.027	2.20	.015	.059
New Bedford	.007	.027	1.65	.012	.045
Pittsfield	.004	.016	1.33	.005	.021
Providence	.008	.061	2.01	.016	.123
Springfield	.012	.050	1.33	.016	.067
Worcester	.018	.069	1.05	.018	.073

2) Automatic inclusion: An area is automatically included for SO_2 if part "b" of the exclusion criterion above is not met. Therefore, Boston is automatically included.

D. Carbon Monoxide (CO)

1) Automatic exclusion: The criterion for automatic exclusion of an SMSA for carbon monoxide concentrations is based on the application of a fairly complicated formula. Carbon monoxide concentrations are considered a function of the ratio of emissions from light duty vehicles to emissions from all vehicles on heavily travelled local streets. This function is expressed as a curve (see Table 6a) provided by EPA.

TABLE 6a. EXCLUSION CRITERIA FOR CARBON MONOXIDE AS A FUNCTION OF THE DISTRIBUTION OF EMISSIONS BETWEEN LIGHT AND HEAVY-DUTY VEHICLES ON LOCAL STREETS



In order to determine whether or not an SMSA qualifies for exclusion, 1970 data on the maximum measured 8-hour concentrations for CO from an air sampling site in a central city must be used. Secondly, an estimate must be made of the proportion of that CO which can be attributed to light duty vehicles. If the intersection of these two items of information is located on the graph below the curve, the area is automatically excluded. Conversely, if the point of intersection of the data falls above the curve, the SMSA is not automatically excluded.

Measured CO data for 1970 was available only for Kenmore Square in the Boston SMSA. Since then, additional sampling sites have been established in the Boston SMSA and in Springfield. For this analysis, it was decided to use the maximum 8-hour concentrations of CO measured in these areas in the past three years. The maximum for the Boston SMSA was recorded in Waltham in 1973: 28 ppm, and in Springfield in the same year: 19 ppm. These levels are indicated on Table 6a.

As for the ratio of light duty vehicles to all vehicles at either site, no firm data is available. EPA suggests that light duty vehicles generally constitute 89% of all vehicles, but in urban areas light duty vehicles represent a lower percentage of all vehicles. Whatever the actual percent, the measured level of CO at the Waltham station was so high that Boston is not excluded. The Springfield SMSA is excluded if we assume light duty vehicles constituted at least 73% of all vehicles: a reasonable assumption. All other SMSAs are automatically excluded for lack of data.

E. Oxidants (Ozone)

1) Automatic Exclusion: An area is automatically excluded for oxidants if a) it has no transportation control strategy for this contaminant: and b) the measured levels of this contaminant within the past two years never rose as high as 0.16 ppm in any one-hour period.

Since Boston and Springfield alone among the Massachusetts SMSAs have transportation control strategies, they obviously do not qualify for exclusion, but all of the other SMSAs do qualify if they meet part b) of the criterion above. In this case, however, as in the case of carbon monoxide, data is not available to test the criterion. As in the preceeding case, EPA has stated that lack of data will justify exclusion, and, therefore, all remaining areas of the State were excluded.

2) Automatic Inclusion: Following upon the exclusion criterion, any area of the State which has a transportation control strategy for oxidants is automatically included. Under this criterion, the Boston and Springfield SMSAs are thus automatically included.

F. Nitrogen Dioxide (NO_2)

1) Automatic Exclusion: Any area not designated by the inclusion criterion for NO_2 is automatically excluded. By this criterion, all SMSAs in Massachusetts are automatically excluded.

2) Automatic Inclusion: The Guidelines specify that only parts of five SMSAs in the nation, none in Massachusetts, are to be automatically included.

IV. EMISSION ANALYSIS

A. Methodology

Based on the outcome of the initial inclusion/exclusion analysis, it was necessary to prepare emission projections for only two contaminants: total suspended particulates (in the Boston, Springfield, Worcester, and Lawrence SMSAs), and carbon monoxide (in the Boston SMSA alone). For the remaining contaminants, all areas of the State were either automatically included or automatically excluded.

Two methods for projecting emissions are offered in the EPA Guidelines. Both of these methods involve an estimation of emissions for 1975 and 1985 by source category through the application of "growth" and "reduction" factors to 1970 emissions. In the "preferred" method, reduction factors unique to the given State and found in its State Implementation Plan are used, while in the "back-up" method, generalized reduction factors provided by EPA are applied. In the Massachusetts analysis, the "preferred" method was used, drawing upon the State Implementation Plan. For both total suspended particulates and carbon monoxide, the analysis of emissions proceeded generally as outlined below.

First, (as shown in column A of the tables included in this part) 1970 emissions of the contaminants from each source category were obtained from appropriate State inventories. Reduction factors (column B) were obtained from the State Implementation Plan. Growth factors (column C) were taken from the OSPM and Manpower Affairs projections. These factors were applied to the data on 1970 emissions to obtain 1975 emissions (column D), except in the categories of power plants and transportation, (vehicular sources), which will be discussed later.

Second, 1975-1985 Growth rates (column E) were derived from the projections on population and the economy prepared by OSPM and the Executive Office of Manpower Affairs. Emission factor adjustments (column F), usually 1.00, were taken from the EPA Guidelines. 1985 emissions (column G) were calculated by applying the growth rate and the emission factor adjustment in the manner indicated in the table heading.

Power plant projections were based independently on information found in the "Load and Capacity Reports" of the planning section of the New England Power Pool (NEPLAN), issued in October, 1973.

For the Boston SMSA, somewhat more complicated sets of calculations were performed, using composites of data for the thirty communities in the region's core and of data for the region's forty-nine outlying communities. For the outlying communities, the most recent complete particulate emissions data is for the year 1966, found in the "1966 Air Pollutant Emission Inventory for the Metropolitan Boston Air Pollution Control District". This data was projected forward to 1970. For the core area, 1970 particulate emissions were taken from the "1970 Air Pollution Emission Inventory for the Metropolitan Boston Air Pollution Control District" (which covers the thirty

core municipalities). For both core and outlying areas, growth rates from OSPM and reduction factors from the State Implementation Plan were applied to the 1970 particulate emission data to provide 1975 emission estimates.

To obtain 1970 CO emission estimates for the total Boston SMSA, an identical composite procedure was followed· however, the projection techniques to estimate 1985 emissions were slightly different. First, it was necessary to separate 1970 CO emissions into two categories, those from non-vehicular sources and those from vehicular sources. The projection of the non-vehicular portion was obtained by a method similar to that used to project particulate emissions, while the projection of the vehicular portion of CO emissions was obtained by the application of a formula provided in the EPA Guidelines.

It should be emphasized that the projections of particulate emission reductions are contingent upon the continued usage of low ash and low sulfur fuels. If the fuel supply problems continue and result in significantly increased usage of high sulfur and high ash fuels, then future particulate emissions will be much higher than those estimated herein.

B. Results: Total Suspended Particulates

1) Boston: As shown in Table 7, total emissions of suspended particulates in the Boston SMSA are projected to decrease from 38,490 tons in 1970 to 23,315 tons in 1975, but then to increase to 38,006 tons in 1985--approximately the same level as in 1970, due to projected population and economic growth.

In the 1970 to 1975 period, major reductions in TSP emissions are expected from commercial, institutional and industrial fuel combustion sources because of requirements for utilization of low ash and low sulphur fuels and the installation of emission controls on facilities. Most of the reductions will, quite naturally, occur in the core area of the region since that is where most TSP emissions are generated. While the volume of commercial, institutional, and industrial activities is expected to grow, both in the outlying part of the region and, to a lesser extent in the core, this growth is not expected to offset the dramatic decreases in TSP pollution from effectuation of the State Implementation Plan. Additional reductions in TSP emissions in the area are expected from decreases in pollution from automobiles and from the continued enforcement of bans on open burning and burning dumps.

From 1975 to 1985, assuming no new controls, continued growth in commercial, institutional and industrial activity in the Boston SMSA is expected to result in a substantial increase of TSP emissions from fuel combustion. A significant increase in emissions in also expected from the heating of residential units. No noticeable increases in emissions are expected from transportation sources, the number of vehicle miles travelled being expected to grow only slightly over the period.

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TABLE 7. EMISSION PROJECTIONS -- TOTAL SUSPENDED PARTICULATES (TONS/YEAR)
BOSTON SMSA

SOURCE CATEGORY	A 1970 EMISSIONS	B REDUCTION FACTOR	C GROWTH FACTOR	D 1975 EMISSIONS	E GROWTH RATE	EMISSION FACTOR ADJUSTMENT	G=D (1+$\frac{1}{2}$F) 1985 EMISSIONS
POWER PLANTS	4247			4039			8834
FUEL COMBUSTION(AREA)							
COMM, INST, AND IND.	8405			6119	0.64	1.0	10035
RESIDENTIAL	5188			4070	0.64	1.0	6675
FUEL COMBUSTION (POINT)							
COM, INST, AND IND.	8308			4952	0.64	1.0	8121
INDUSTRIAL PROCESS (POINT)	302			66	0.09	0.4	68
SOLID WASTE DISPOSAL(AREA)		---					
INCINERATION	1948	SEE TABLES 7a and 7b FOR		519	0.05	1.0	545
OPEN BURNING	134	APPLICABLE GROWTH AND		0			0
		REDUCTION FACTORS					
SOLID WASTE DISPOSAL(POINT)							
INCINERATION	948			136	0.05	1.0	143
BURNING DUMPS	1830			0			0
TRANSPORTATION							
LDV }							
HDV }	5579			2680	0.05	1.0	2814
MISCELLANEOUS (POINT)	1601			734	0.05	1.0	771
TOTAL	38490			23315			38006

| | | |

TABLE 7a. EMISSION PROJECTIONS - - TOTAL SUSPENDED PARTICULATES (TONS/YEAR)

30 CORE COMMUNITIES IN BOSTON SMSA

SOURCE CATEGORY	A 1970 EMISSIONS	B REDUCTION FACTOR	C GROWTH FACTOR	D 1975 EMISSIONS	E GROWTH RATE	F EMISSION FACTOR ADJUSTMENT	G=D(1+EF) 1985 EMISSIONS
POWER PLANTS	3090			2755			4428
FUEL COMBUSTION (AREA)							
COM, INST, AND IND.	6565	0.69	1.11	4995			
RESIDENTIAL	3987	0.73	1.11	3223			
FUEL COMBUSTION (POINT)							
COMM, INST, AND IND.	5314	0.51	1.11	3024			
INDUSTRIAL PROCESS (POINT)	302	0.23	0.96	66			
SOLID WASTE DISPOSAL (AREA)						SEE TABLE 7 FOR APPLICABLE GROWTH RATES AND EMISSIONS FACTOR ADJUSTMENTS	
INCINERATION	1733	0.25	1.02	440			
OPEN BURNING	0			0			
SOLID WASTE DISPOSAL (POINT)							
INCINERATION							
BURNING DUMPS	732	0.14	1.02	105			
TRANSPORTATION							
LDV }	3264	0.45	1.02	1499			
HDV }							
MISCELLANEOUS (POINT)	1601	0.45	1.02	734			
TOTAL	26598			16841			

0°14' 1°05'

0°30' 1°05'

TABLE 7b. EMISSION PROJECTIONS - - TOTAL SUSPENDED PARTICULATES (TONS/YEAR)

49 OUTLYING COMMUNITIES IN BOSTON SMSA

SOURCE CATEGORY	A 1970 EMISSIONS	B REDUCTION FACTOR	C GROWTH FACTOR	D 1975 EMISSIONS	E GROWTH RATE	F EMISSION FACTOR ADJUSTMENT	G=D (1+EF) 1985 EMISSIONS
POWER PLANTS	1157			1284			4409
FUEL COMBUSTION (AREA)							
COMM, INST, AND IND.	1840	0.55	1.11	1124			
RESIDENTIAL	1191	0.64	1.11	847			
FUEL COMBUSTION (POINT)							
COMM, INST, AND IND.	2994	0.58	1.11	1928			
INDUSTRIAL PROCESS (POINT)	0			0			
SOLID WASTE DISPOSAL (AREA)							
INCINERATION	215	0.36	1.02	79		SEE TABLE 7 FOR APPLICABLE GROWTH	
OPEN BURNING	134			0		RATES AND EMISSION	
SOLID WASTE DISPOSAL (POINT)						FACTORS ADJUSTMENT	
INCINERATION	216	0.14	1.02	31		---	
BURNING DUMPS	1830			0			
TRANSPORTATION							
LDV							
HDV	2315	0.5	1.02	1181			
MISCELLANEOUS (POINT)	0			0			
TOTAL	11892			6474			

2) Springfield: As shown in Table 8, total emissions of suspended particulates in the Springfield SMSA are projected to decline from 22,940 tons in 1970 to only 4,126 tons in 1975, rising slightly to 4,780 tons by 1985.

The major factor contributing to the reduction of TSP emissions in the Springfield area is the conversion of power plants in the area from coal to oil. This conversion alone has already resulted in a significant drop in emissions and will result in a drop of 7,906 tons of TSP emissions by 1975. Added to this reduction will be another important reduction in emissions from commercial, institutional and industrial sources, resulting mainly from the conversion from coal to oil of the University of Massachusetts at Amherst and of Amherst College. (Note that for this analysis the Town of Amherst has been substituted for the Town of Webster in the SMSA, because of meteorological considerations). Other significant reductions will be realized in emissions resulting from process losses and from transportation activities.

Although growth in the economy and population of the Springfield area is projected for the period 1975 to 1985, this growth is not expected to offset to any significant degree the dramatic reduction in TSP emissions expected to occur in the earlier period.

	0'32	1'	
	0'53	0'03	
	0'02	1'05	

TABLE. 8 EMISSION PROJECTIONS - - TOTAL SUSPENDED PARTICULATES (TONS/YEAR)

SPRINGFIELD SMSA

SOURCE CATEGORY	A 1970 EMISSIONS	B REDUCTION FACTOR	C GROWTH FACTOR	D 1975 EMISSIONS	E GROWTH RATE	F EMISSION FACTOR ADJUSTMENT	G=D (1+EF) 1985 EMISSIONS
POWER PLANTS	8555			649			649
FUEL COMBUSTION (AREA)							
COMM, INST, AND IND.	813	0.55	1.02	456	0.30	1.0	594
RESIDENTIAL	677	0.64	1.02	442	0.30	1.0	575
FUEL COMBUSTION (POINT)							
COMM, INST, AND IND.	6066	0.03	1.02	186	0.30	1.0	241
INDUSTRIAL PROCESS (POINT)	2658	0.23	0.93	569	-0.01	1.0*	563
SOLID WASTE DISPOSAL (AREA)							
INCINERATION	522	0.36	1.02	192	0.05	1.0	202
OPEN BURNING	531			0			0
SOLID WASTE DISPOSAL (POINT)							
INCINERATION	693	0.14	1.02	99	0.05	1.0	104
BURNING DUMPS	383			0			0
TRANSPORTATION							
LDV							
HDV	1078	0.50	1.02	550	0.05	1.0	583
MISCELLANEOUS (POINT)	964	1.00	1.02	983	0.30	1.0	1278
TOTAL	22940			4126			4789

*No Emission Factor Adjustment since Growth Rate is negative.

3) Worcester: As shown in Table 9, emissions of suspended particulates in the Worcester SMSA are expected to decline from 8,641 tons in 1970 to only 1,866 tons in 1975, increasing slightly to the level of 1,992 tons by 1985.

The major factor leading to the reduction of TSP emissions in the Worcester SMSA is the closing of the Webster Square power plant responsible for 3,168 tons of TSP emissions in 1970. Small but cumulatively significant reductions in TSP emissions are expected also from fuel combustion sources, incineration, waste disposal, and transportation.

Minimal growth is expected in the Worcester SMSA from 1975 to 1985 and such growth will lead to only a small increase in TSP emissions.

TABLE 9. EMISSION PROJECTIONS - - TOTAL SUSPENDED PARTICULATES (TONS/YEAR)

WORCESTER AREA

SOURCE CATEGORY	A 1970 EMISSIONS	B REDUCTION FACTOR	C GROWTH FACTOR	D 1975 EMISSIONS	E GROWTH RATE	F EMISSION FACTOR ADJUSTMENT	G=D (1+EF) 1985 EMISSIONS
POWER PLANTS	3168			0			0
FUEL COMBUSTION (AREA)							
COMM, INST, AND IND.	789	0.55	0.96	416	0.09	1.0	455
RESIDENTIAL	573	0.64	0.96	308	0.09	1.0	337
FUEL COMBUSTION (POINT)							
COMM, INST, AND IND.	908	0.58	0.96	505	0.09	1.0	553
INDUSTRIAL PROCESS (POINT)	202	0.23	0.89	41	-0.16	1.0*	34
SOLID WASTE DISPOSAL (AREA)							
INCINERATION	436	0.36	1.00	156	0.03	1.0	160
OPEN BURNING	58			0			0
SOLID WASTE DISPOSAL (POINT)							
INCINERATION	984	0.14	1.00	137	0.03	1.0	141
BURNING DUMPS	914			0			0
TRANSPORTATION							
LDV	595	0.50	1.00	296	0.03	1.0	305
HDV							
MISCELLANEOUS (POINT)	14	0.50	1.00	7	0.03	1.0	7
TOTAL	8641			1866			1992

*No Emission Factor Admustment since Growth Rate is negative.

4) Lawrence: As shown in Table 10, total emissions of suspended particulates in the Lawrence SMSA are projected to decline from 2,115 tons in 1970 to 1,050 tons in 1975, increasing to 1,289 tons in 1985.

The over-all reduction in emissions in the area from 1970 to 1975 is expected to be spread fairly evenly among reductions from various sources. In the period 1975 to 1985, growth in fuel combustion associated with commercial, institutional and industrial activities is expected to account for the major part of additional emissions, with some rise projected also from residential heating.

		0.38	
		0.53	0.82

TABLE 10. EMISSION PROJECTIONS - - TOTAL SUSPENDED PARTICULATES (TONS/YEAR)

LAWRENCE SMSA

SOURCE CATEGORY	A 1970 EMISSIONS	B REDUCTION FACTOR	C GROWTH FACTOR	D 1975 EMISSIONS	E GROWTH RATE	F EMISSION FACTOR ADJUSTMENT	G=D (1+EF) 1985 EMISSIONS
POWER PLANTS	0			0			0
FUEL COMBUSTION (AREA)							
COMM, INST, AND IND.	403	0.55	1.02	226	0.30	1.0	294
RESIDENTIAL	291	0.64	1.02	190	0.30	1.0	247
FUEL COMBUSTION (POINT)							
COMM, INST, AND IND.	514	0.58	1.02	304	0.30	1.0	395
INDUSTRIAL PROCESS (POINT)	63	0.23	0.96	14	0.09	0.4	15
SOLID WASTE DISPOSAL (AREA)							
INCINERATION	262	0.36	1.03	97	0.07	1.0	104
OPEN BURNING	15			0			0
SOLID WASTE DISPOSAL (POINT)							
INCINERATION	154	0.14	1.03	22	0.07	1.0	24
BURNING DUMPS	30			0			0
TRANSPORTATION							
LDV							
HDV	371	0.50	1.03	191	0.07	1.0	204
MISCELLANEOUS (POINT)	12	0.50	1.03	6	0.07	1.0	6
TOTAL	2115			1050			1289

C. Results: Carbon Monoxide

As noted above, an analysis of carbon monoxide emissions was required only for the Boston SMSA. The analysis shows that CO emissions in the region, which amounted to 1,019,292 tons in 1970, are likely to drop to 204,535 tons in 1985, a reduction of approximately 80%. The major factor behind this expected decrease in emissions is the national vehicle emissions control program.

As seen in Table 11, emissions from transportation sources account for the overwhelming share of CO emissions (998,460 tons out of 1,019,292 tons in 1970). From 1970 to 1985, CO emissions from transportation sources are projected to drop to 185,667 tons. It should be noted that CO emissions from fuel combustion sources (including power plants) are projected to rise. However, these sources contribute relatively little to the over-all problem.

TABLE 11. EMISSION PROJECTIONS - - CARBON MONOXIDE (TONS/YEAR)

BOSTON SMSA

SOURCE CATEGORY	A 1970 EMISSIONS	B REDUCTION FACTOR	C GROWTH FACTOR	D 1975 EMISSIONS	E GROWTH RATE	F EMISSION FACTOR ADJUSTMENT	G=D (1+EF) 1985 EMISSIONS
POWER PLANTS	1593			2017			4403
FUEL COMBUSTION (AREA							
COMM,INST, AND IND.	403	1.00	1.11	447	0.64	1.0	733
RESIDENTIAL	3249	1.00	1.11	3606	0.64	1.0	5914
FUEL COMBUSTION (POINT)							
COMM, INST, AND IND.	73	1.00	1.11	81	0.64	1.0	133
INDUSTRIAL PROCESS (POINT)	146	0.10	0.96	14	0.09	0.4	6
SOLID WASTE DISPOSAL (AREA)							
INCINERATION	974	0.88	1.02	874	0.05	1.0	918
OPEN BURNING	712			0			0
SOLID WASTE DISPOSAL (POINT)							
INCINERATION	354	0.52	1.02	188	0.05	1.0	197
BURNING DUMPS	9722			0			0
TRANSPORTATION							
LDV	887520						75688
HDV	110940						109984
MISCELLANEOUS (POINT)	3606	1.0	1.11	4003	0.64	1.0	6565
TOTAL	1019292						204535

V. AIR QUALITY ANALYSIS

A. Estimation Approaches

Estimates of air quality were required, following the emissions analysis, for total suspended particulates in four SMSAs -- Boston, Springfield, Worcester, and Lawrence. Only for one SMSA, Boston, was there a need to estimate air quality in terms of carbon monoxide. Based on the air quality analyses performed, it is recommended that all four SMSAs be designated as Air Quality Maintenance Areas for particulates and that none be designated for carbon monoxide.

The air quality analyses indicated clearly that Boston should be designated for particulates and that Boston should not be designated for carbon monoxide. Findings of the particulates analyses for Springfield, Worcester, and Lawrence were contradictory. It is suggested that the conservative approach would be to designate these three areas, in addition to Boston, for particulates at this stage, and that the detailed analysis then required in the second stage of the planning process be used to confirm, modify, or revoke these designations. The EPA Guidelines suggest precisely this procedure in cases where findings are not clear-cut.

The Guidelines offered a choice of three models to derive estimates of future air quality in terms of particulates: the "rollforward" method, the "Miller-Holzworth" method, and the "Larsen (log-normal)" method. The general nature of each of these models is described below, as are the weaknesses of each. Because of the severe limitations of the "Miller-Holzworth" method, it was not utilized to estimate particulate air quality. Instead, the remaining two models were applied and the results obtained were compared. For carbon monoxide, a single estimation procedure was used, which is explained in Part C below.

1) The Rollforward Model: This is a formula in which projected concentrations of particulates are derived as a function of the sum of background concentrations of TSP, plus the difference between the baselines and background concentrations multiplied by the ratio of projected emissions to baseline emissions. This model is limited in that it does not consider meteorology and in that it relates emissions to a single monitoring site.

2) The Miller-Holzworth Model: With this technique, the average annual city-wide concentration of a contaminant is calculated as a function of emission density and certain meteorological factors (wind distance, wind speed and mixing depth). The model's major weakness is that it does not relate well to measured levels of air quality. In a sample calculation for the Boston SMSA, this model predicted an average annual concentration for particulates of 25 ug/m^3, which is below the background level in the SMSA. Clearly, the model seriously under-predicts air quality and, for this reason, it was not used.

3) Larsen's (log-normal) Model: This model provides for the estimation of short-term maximum concentrations of a contaminant, and suggests simply

that there is a direct relationship between short-term maximum and annual average concentrations of the given contaminant. The model may overpredict short-term concentrations and requires estimates of average annual concentrations for its application. It should be noted that the log-normal method predicts "highest" 24-hour levels, not "second highest" 24-hour levels, as stated in the standard. Analysis by this method, therefore, will tend to include SMSAs which may drop out upon further and more detailed study.

B. Total Suspended Particulates (TSP)

Table 12 below summarizes the results obtained by applying the rollforward and Larsen models to determine particulate concentrations in the Boston, Springfield, Worcester, and Lawrence SMSAs. The national ambient air quality standards against which these results are compared are as follows: a) the average annual concentrations may not exceed 75 ug/m^3; and b) the second highest 24-hour concentration may not exceed 150 ug/m^3. The table shows that, by the rollforward method, only Boston (with an estimated 1985 annual concentration of 88 ug/m^3 and an estimated 1985 24-hour concentration of 230 ug/m^3) requires designation as an Air Quality Maintenance Area. By the log-normal method, on the other hand, all four SMSAs appear to require designation, because of estimated 1985 24-hour concentrations of 334 ug/m^3 (Boston), 151 ug/m^3 (Springfield), 209 ug/m^3 (Worcester), and 203 ug/m^3 (Lawrence).

1) Rollforward Analysis:

The proportional rollforward model utilizes the following equation:

$$C_{1985} = b + (C_{base} - b)\frac{Q_{1985}}{Q_{base}}$$

Where:

C_{1985} = projected concentration

b = background concentration

C_{base} = baseline concentration

Q_{1985} = projected emission

Q_{base} = baseline emission

The numerical values for baseline emissions were obtained from the emission projection tables in the preceeding section. Baseline concentrations were taken from Table 13 below, which presents values for air quality in the selected base years. The background concentration was taken to be 31 ug/m^3. This is the level recorded at Maynard, a lightly settled area in the Boston District. Taking these values for each SMSA, the following results were obtained:

TABLE 12. SUMMARY OF ESTIMATIONS OF 1985 TOTAL SUSPENDED PARTICULATE (TSP) LEVELS

(Micrograms per cubic meter (ug/m^3))

SMSA	Measured Annual Average, Base Year	Estimated Annual Average, 1985 (Rollforward Method)	Measured 2nd Highest 24 Hour, Base Year	Estimated 2nd, Highest 24 Hour 1985 (Rollforward Method)	Estimated Highest 24 Hour, 1985 (Log-normal Method)
Boston	89	88	233	230	334
Lawrence-Haverhill	66	52	156	106	203
Worcester	90	45	295	92	209
Springfield	110	47	285	84	151

TABLE 13

SELECTED BASE YEAR AIR QUALITY LEVELS (TSP)

Site	Base Year	Measured Annual Geometric Mean (baseline concentration)	Measured 2nd Highest 24 hour (baseline concentration)
JFK Building Boston	1970	89	233
Hamblett Foundry Lawrence	1970*	66	156
Narcus Department Store Worcester	1972+	90	295
Taylor Street Springfield	1969++	110	285

*Based on partial year
+No data available for 1970
++Consistent with 1969 emission inventory

$$\frac{\quad}{20340} = \quad$$

$$\frac{\quad}{8647} = 15 \quad \text{g/m}^3$$

Boston SMSA:

Annual Average

$$C_{1985} = 31 + (89-31)\ \frac{38006}{38490} = 88\ ug/m^3$$

2nd Highest 24 hour

$$C_{1985} = 31 + (233-31)\ \frac{38006}{38490} = 230\ ug/m^3$$

Springfield SMSA:

Annual Average

$$C_{1985} = 31 + (110-31)\ \frac{4789}{22940} = 47\ ug/m^3$$

2nd Highest 24 hour

$$C_{1985} = 31 + (285-31)\ \frac{4789}{22940} = 84\ ug/m^3$$

Worcester SMSA:

Annual Average

$$C_{1985} = 31 + (90-31)\ \frac{1992}{8641} = 45\ ug/m^3$$

2nd Highest 24 hour

$$C_{1985} = 31 + (295-31)\ \frac{1992}{8641} = 92\ ug/m^3$$

Lawrence SMSA:

Annual Average

$$C_{1985} = 31 + (66-31)\ \frac{1274}{2115} = 52\ ug/m^3$$

2nd Highest 24 hour

$$C_{1985} = 31 + (156-31)\ \frac{1274}{2115} = 106\ ug/m^3$$

2) Larsen (log-normal) Analysis:

In addition to the rollforward prediction of the second highest 24-hour concentration. the Larsen (log-normal) model was applied to the

predicted 1985 annual average concentration to obtain the highest 24-hour concentration. The end product is in fact a composite rollforward and log-normal prediction, since the 1985 annual average concentration was obtained by using the rollforward model.

The log-normal model is an empirecal relationship developed by Dr. Larsen of EPA. This relationship has been expressed as a table provided by the Guidelines. Using this table, the estimated peak concentration of a contaminant may be calculated from the annual average, provided that the geometrical standard deviation of the sampling data is known.

Table 14 below provides the geometric standard deviations for the four SMSAs, and indicates the appropriate log-normal ratios. The predicted 1985 annual average concentrations are then multiplied by these ratios, to yield the estimated maximum 24-hour values.

The calculations which predict log-normal maximum 24-hour values for each SMSA are shown below:

Boston: Maximum 24-hour = 3.80 (88) = 344 ug/m^3

Springfield: Maximum 24-hour = 3.21 (47) = 151 ug/m^3

Worcester: Maximum 24-hour = 4.64 (45) = 209 ug/m^3

Lawrence-Haverhill: Maximum 24-hour = 3.90 (52) = 203 ug/m^3

C. Results: Carbon Monoxide

For the Boston SMSA, a formula suggested in the EPA Guidelines was used to predict 1985 carbon monoxide concentrations. Its application to data for the SMSA yielded a 1985 CO concentration of 5.1 ppm. As the national standard is 9 ppm, Boston need not be designated as an Air Quality Maintenance Area for carbon monoxide.

The recommended formula was:

$$F_t = F_l + F_u + b$$

$$\frac{F_l}{0.8\ (B-b)} = \frac{P_l G^*_l E_l + P_h G^*_h E_h}{P_l + P_h}$$

$$\frac{F_u}{0.2\ (B-b)} = \frac{P_l G_l E_l + P_h G_h E_h + P_s G_s E_s}{100\%}$$

where:

F_t = Total Future (1985) CO concentrations (PPM)

F_l = Future concentration due to local traffic

F_u = Future concentration due to urban emissions

57.1

TABLE 14

SELECTED BASE YEAR GEOMETRIC STANDARD DEVIATIONS & LOG-NORMAL RATIOS

Site	Base Year	Geometric Standard Deviations	Log-Normal Ratios
JFK Building Boston	1970	1.63	3.80
Hamblett Foundry Lawrence	1970	1.66	3.90
Narcus Department Store, Worcester	1972	1.78	4.64
Taylor Street Springfield	1969	1.53	3.21

Continued -

b = Background concentration

B = Baseline concentration (measured)

P_l = Percent emission from light duty vehicles (1970)

P_h = Percent emissions from other mobile sources (1970)

P_s = Percent emissions from stationary sources (1970)

G = Growth factor over the projected period

G* = Growth factor for local street traffic over the projected period

E = Expected ratio of 1985 emission to baseline emission for a composite source

The following values were used in working out the calculations:

b = 1 ppm (as suggested in the Guidelines)

B = 28 ppm (highest measured 8 hour average in the SMSA)

P_S = 2 (from Table 11 the percentage of CO emissions due to non-vehicular sources was obtained)

$P_L = P_H = 98$ and $\frac{P_L}{P_H} = 8$ (as recommended in the Guidelines)

Thus $P_L = 87$ and $P_H = 11$

$G_L = G_H = 1.066$ (from Table 2, 1970-1985 population growth)

$G^*_L = G^*_H = 1.0$ (from the Guidelines)

$E_H = 0.93$ (from the Guidelines)

$E_L = 0.08$ (from the Guidelines)

$P_S G_S E_S$ = the ratio of 1985 non-vehicular emissions to total 1985 emissions

$= \frac{18865}{204535} = 9\%$ (Table 11).

Thus the equation becomes:

$$F_l = 0.8\ (28-1)\ \frac{(87)(1.0)(0.08) + 11\ (1.0)(0.93)}{98}$$

$$= 0.8\ (27)\ \frac{7+10}{98} = 3.7$$

$$F_u = 0.2\ (28-1)\quad \frac{(87)(1.06)(0.08) + (11)(1.06)(0.93) + (9)}{100}$$

$$= 0.2\ (27)\quad \frac{7.4 + 10.8 + 9}{100} = 1.4$$

$$F_t = F_1 + F_u = 5.1 \text{ ppm}$$

Thus the estimated 1985 CO concentration is 5.1 ppm.

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